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MECHANISM AND KINETICS OF FORMATION OF INTERMETALLIC LAYERS ON THE SURFACE OF STEEL PRESS MOLDS IN CASTING OF SILUMINS

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Regular features of the mechanism and kinetics of formation of transition layers under interaction between castable silumins and die steel 4KhVMFS (DI-22) used for making press molds are determined. The process of dissolution of the material of the press molds in AL-2 (AK12) silumin is accompanied by formation of aluminum-enriched intermetallic compounds of $FeAl_3$ and Al_4Si_2Fe types and then by formation of Fe_2Al_5 and Fe_3Al intermetallic compounds with elevated iron content on the contact surface. Cross diffusion of aluminum is activated in regions under the continuous intermetallic layer on the surface of the mold and causes formation of a layer of a solid solution of aluminum in the steel, which is responsible for sticking of the material of the casting to the mold.

Key words: die steel, silumin, intermetallic compounds, thermomechanical fatigue cracks, microhardness, x-ray diffraction and metallographic analysis.

INTRODUCTION

Fracture of the working surfaces of press molds for pressure casting of aluminum-base alloys (ALPD) depends largely on the activity of the processes of physicochemical interaction between the tool material and the cast melt. Typical kinds of damage manifest themselves in changes in the size stability of the mold components connected with burn-on (sticking) of the material of the castings to the working surfaces (Fig. 1). In addition, fatigue processes are activated on the shaping surfaces of the press molds upon contact with molten silumins under the conditions of intense cyclic temperature-force loading and cause defects in the form of thermomechanical fatigue (TMF) cracks (Fig. 2). Such defects as caverns and pits are frequently encountered in the bull crucibles of pressure casting machine parts and on distributing surfaces of cavity inserts of ALPD in contact with the moving silumin melt (Fig. 3). The dissolution of the material of the press molds in silumins is explainable by the fact that the cast silumins, alloy AL-2 (AK12) in particular, play the role of unsaturated iron with respect to aluminum [1, 2].

It is shown in [3, 4] that the material of a silumin casting sticks to the surface of the press mold due to diffusion of aluminum into the die steel. This inference is made with allowance for the laws of diffusion in the steel-aluminum system, which are typical for the processes of aluminizing and do not reflect the actual conditions of interaction between silumins and the material of press molds.

The aim of the present work was to determine the regular features of formation of defects on the surfaces of ALPD press molds due to physicochemical interaction between molten silumins and die steels under the specific conditions of the operational loading of press tools.

METHODS OF STUDY

We studied the regular features of interaction between silumins and steel surface for rods from steel 4KhVMFS (DI-2). The rod specimens had a length of 80 mm, a functional part forming openings in the test castings 12 mm long, and a diameter of 5 mm. The cast alloy was silumin of grade AL-2 (AK-12) (GOST 1583–93) with the following composition (in wt.%): 12.0 Si, 1 Fe, 0.1 Mg, 0.5 Mn, 0.6 Cu, 0.2 Zn, the remainder Al.

The studies were performed at the KAMAZ Company for VOTAN-type machines at a pressure of ≈ 1200 MPa in

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